UTILIZATION OF SOURSOP LEAF EXTRACT AS A BOTANICAL PESTICIDE FOR POTTED TOMATO PLANTS

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ABSTRACT

Tomato (Solanum lycopersicum) is an important horticultural commodity that can be cultivated in urban areas using household-scale containers and pots. However, potted tomato plants are vulnerable to insect pests, particularly aphids, thrips, and armyworms, which can damage leaves, inhibit plant growth, and reduce productivity. In Ceger, Tegal Gundil Subdistrict, Bogor City, residents cultivate tomatoes in limited residential spaces and generally rely on conventional pest-control practices. The use of synthetic pesticides may increase production costs and raise concerns about pesticide residues, environmental exposure, and non-target effects. Therefore, this community service program aimed to improve participants' knowledge and practical skills in using soursop (Annona muricata) leaf extract as a botanical pesticide for potted tomato plants. The program employed a participatory and applicative approach comprising preliminary observation, environmental and agricultural education, demonstration, hands-on training, botanical pesticide application, and evaluation. Participants learned about the pesticidal potential of soursop leaves and practiced extract preparation and application. Changes in participants' perceptions were evaluated by comparing responses before and after the intervention, while pest conditions were observed following application. The results showed a positive shift in participants' perceptions and increased confidence in preparing and applying botanical pesticides. Observations also indicated reductions in pest populations and leaf damage after application. These findings suggest that soursop leaf extract has potential as a locally accessible and environmentally oriented pest-management option for household-scale tomato cultivation. However, controlled experiments are needed to determine its efficacy, optimal concentration, application frequency, and effects on beneficial organisms.

Keywords: Soursop Leaves, Botanical Pesticide, Potted Tomatoes, Urban Farming, Community Service.

1. INTRODUCTION

Urbanization and increasing population density have reduced the availability of conventional agricultural land while simultaneously increasing the need for household food production. In urban environments, home gardens, containers, and potted plants provide practical alternatives for residents with limited access to agricultural land. Household-scale urban farming can contribute to food availability while utilizing otherwise underused residential spaces. Tomato (*Solanum lycopersicum*) is one of the horticultural crops suitable for this type of cultivation because of its economic and nutritional value and its adaptability to small-scale production systems.

Despite these advantages, potted tomato cultivation remains susceptible to insect pest attacks. Aphids, thrips, and caterpillar-type pests can attack leaves and young plant tissues, interfere with plant development, and potentially reduce crop productivity. In small-scale urban farming systems, pest management can be challenging because household growers may have limited knowledge of integrated pest management and may select pest-control methods based primarily on availability and familiarity. Consequently, synthetic pesticides may become a preferred option for managing pest infestations. The use of chemical pesticides remains common in vegetable production because of their rapid action and perceived effectiveness; however, their application requires appropriate management to minimize adverse environmental and agricultural consequences (Ngegba et al., 2022; Lalruatsangi, 2022).

The inappropriate or excessive use of synthetic pesticides may result in several environmental and agricultural concerns, including pesticide residues, contamination of surrounding environments, adverse effects on non-target organisms, and the development of pest resistance. These concerns have encouraged increasing attention to botanical pesticides as potential components of environmentally oriented and integrated pest management. Botanical pesticides are derived from plants and contain bioactive secondary metabolites that may exhibit insecticidal, repellent, antifeedant, growth-regulating, or other biological activities against insect pests (Lengai et al., 2020; Merchant, 2022; Tian et al., 2022). Botanical pesticides may therefore provide an environmentally oriented option for reducing reliance on synthetic pesticides, particularly when integrated with other non-chemical pest-management practices. Nevertheless, botanical pesticides should be regarded as complementary pest-management tools rather than automatic

substitutes for all synthetic pesticides because their effectiveness and application requirements vary according to the target pest, plant material, formulation, and environmental conditions (Lalruatsangi, 2022; Shai et al., 2024).

Soursop (*Annona muricata* L.) is one locally available plant with potential for botanical pesticide development. Different parts of *A. muricata* contain diverse phytochemical constituents, including alkaloids, phenolic compounds, flavonoids, and annonaceous acetogenins. In particular, annonaceous acetogenins represent characteristic bioactive compounds of the Annonaceae family and have been associated with various biological activities (Mutakin et al., 2022). The biological properties of *A. muricata* have attracted attention for potential applications in agricultural pest management, although the activity of extracts may differ according to the plant part, extraction procedure, chemical composition, and target organism (Lengai et al., 2020; Merchant, 2022). Previous studies have reported insecticidal or biopesticidal activity of *A. muricata* extracts against several insect pests. Khoirunnisya et al. (2022), for example, investigated the toxicity of *A. muricata* leaf extract against *Spodoptera frugiperda*, demonstrating the relevance of soursop leaves as a potential botanical insecticide. Similarly, Mohammad et al. (2023) reported insecticidal activity of selected medicinal plant extracts, including *A. muricata*, against *Sitophilus zeamais*. These findings support the potential of *A. muricata* as a source of plant-derived pest-management compounds, while also indicating that biological activity should be evaluated in relation to the specific target pest and application context (Khoirunnisya et al., 2022; Mohammad et al., 2023).

However, evidence of pesticidal activity against particular insect species cannot automatically be interpreted as evidence of effectiveness against aphids, thrips, or armyworms attacking tomato plants. The effectiveness of botanical pesticides can vary according to the plant material, extraction method, concentration, target pest, environmental conditions, and application technique (Lengai et al., 2020; Lalruatsangi, 2022; Shai et al., 2024). Therefore, community-based demonstrations can serve as an important initial approach for introducing botanical pesticide technology, developing users' practical skills, and observing its potential application under actual household cultivation conditions. Such activities are particularly relevant where locally available botanical resources can be incorporated into environmentally oriented agricultural practices (Rudianto et al., 2025).

The community in Ceger, Tegal Gundil Subdistrict, Bogor City, is an appropriate setting for introducing locally adaptable pest-management practices. Residents utilize home yards and limited spaces to cultivate vegetables and tomatoes, but pest attacks remain one of the constraints to successful potted tomato cultivation. Under these conditions, pest-management technologies should not only address pest problems but also be simple to prepare, accessible to households, economically feasible, and compatible with environmentally oriented cultivation practices. The introduction of botanical pesticides through participatory education and hands-on training can help strengthen community knowledge and practical capacity while promoting the utilization of locally available plant resources (Rudianto et al., 2025; Shai et al., 2024). Community-based agricultural interventions can also contribute to broader environmental education and sustainable household resource utilization. Previous community service activities have demonstrated the importance of participatory learning, practical demonstrations, and the utilization of locally available biological resources in strengthening community capacity for environmentally oriented practices (Sukamdani et al., 2024; Sukwika, 2022; Sukwika & Paranita, 2025). In this context, the introduction of soursop leaf extract as a potential botanical pesticide is not limited to pest suppression but also provides an opportunity to promote community awareness regarding the utilization of locally available plant resources and the adoption of more environmentally responsible cultivation practices.

Based on these conditions, this community service program aimed to introduce and demonstrate the utilization of soursop leaf extract as a botanical pesticide for potted tomato plants. Specifically, the program aimed to: (1) improve participants' knowledge of environmentally oriented pest management; (2) introduce the potential pesticidal properties of soursop leaves; (3) improve participants' practical skills in preparing and applying botanical pesticides; and (4) observe changes in pest attack conditions on potted tomato plants following application. The activity was designed as a participatory and applicative community intervention, emphasizing knowledge transfer, hands-on practice, and field-based observation rather than controlled experimental validation.

2. METHOD

Location and Participants

The community service program was conducted with residents involved in household-scale urban farming in Ceger, Tegal Gundil Subdistrict, Bogor City, Indonesia. Participants were residents who cultivated vegetables and tomatoes using home yards, containers, or other limited spaces.

Participants were selected based on their involvement in household cultivation activities, availability of potted tomato plants, interest in environmentally friendly cultivation practices, and willingness to participate in educational, training,

and practical activities. This participant-oriented approach was intended to ensure that the intervention was relevant to the actual cultivation conditions, pest-management needs, and resource availability of the target community. Community-based agricultural training that incorporates locally available botanical resources can facilitate the introduction of environmentally oriented pest-management practices at the household level (Rudianto et al., 2025; Shai et al., 2024).

Activity Design

The activity adopted a participatory and applicative approach that emphasized both knowledge transfer and the development of participants' practical skills. The approach was designed to enable participants not only to understand the basic concepts of botanical pesticides and environmentally oriented pest management but also to recognize pest problems, prepare botanical pesticide formulations, apply the treatment to potted tomato plants, and observe plant responses following application. A participatory approach is particularly relevant to community-based agricultural interventions because the successful utilization of botanical pesticides depends not only on their potential biological activity but also on users' knowledge, practical skills, accessibility of materials, and confidence in application (Lalruatsangi, 2022; Shai et al., 2024).

The implementation was conducted through four sequential stages: preliminary observation and identification of community needs, environmental and agricultural education, demonstration and hands-on practice of botanical pesticide preparation and application, and evaluation and monitoring. The preliminary observation was conducted to understand the existing conditions of household-scale tomato cultivation and the pest-management problems encountered by residents. This was followed by educational activities introducing participants to botanical pesticides, the potential of soursop leaves, and environmentally oriented pest-management practices. The demonstration and hands-on practice then provided participants with direct experience in preparing and applying the soursop leaf extract to potted tomato plants. Finally, evaluation and monitoring were conducted to assess changes in participants' understanding, practical abilities, perceptions, and observed pest attack conditions following the intervention.

The sequential integration of education, practical demonstration, application, and monitoring is consistent with the application of botanical pesticides as part of integrated pest management, in which botanical materials are considered complementary tools that should be appropriately selected and applied according to target pests and cultivation conditions (Lengai et al., 2020; Tian et al., 2022; Merchant, 2022). Through this participatory approach, residents were actively involved throughout the learning process rather than functioning solely as recipients of information. Their direct involvement in identifying pest problems, preparing the botanical pesticide, applying the treatment, and observing plant responses was intended to strengthen both their understanding and practical confidence in utilizing soursop leaf extract as a potential botanical pesticide. Similar community-based approaches emphasize hands-on learning and the practical utilization of botanical resources as mechanisms for strengthening community capacity in sustainable agricultural practices (Rudianto et al., 2025).

Preliminary Observation

Preliminary observation was conducted to identify the existing conditions of household-scale tomato cultivation and the pest problems experienced by residents. The observation involved direct discussions with participants regarding their cultivation practices, the types and characteristics of pests encountered, commonly used pest-control methods, difficulties in maintaining potted tomato plants, and their existing understanding of botanical pesticides. Particular attention was also given to the type and condition of the potted tomato plants, visible symptoms of insect pest attacks, and the availability of soursop leaves as a locally accessible plant resource. In addition, participants' expectations and needs regarding the planned education and training activities were identified to ensure that the intervention was relevant to the conditions of the target community.

The information obtained during the preliminary observation was subsequently used as a basis for developing the educational materials, demonstration activities, and hands-on practical components of the community service program. This initial assessment enabled the program to address the participants' actual cultivation conditions and pest-management needs while introducing the utilization of locally available soursop leaves as a potential botanical pesticide for potted tomato plants. The use of locally available botanical materials is relevant to sustainable pest management because accessibility and practicality are important considerations in the adoption of botanical pesticide technologies, particularly in small-scale farming systems (Lengai et al., 2020; Shai et al., 2024).

Education and Training

The educational session introduced participants to botanical pesticides and the potential utilization of plant-derived materials in sustainable pest management. The training emphasized that botanical pesticides can function as alternative or complementary tools within integrated pest management and should not automatically be regarded as complete

replacements for synthetic pesticides. Botanical pesticides contain plant-derived bioactive compounds that may exhibit insecticidal, repellent, antifeedant, growth-regulating, or other biological activities, but their effectiveness depends on the plant source, target pest, formulation, concentration, and application conditions (Lengai et al., 2020; Lalruatsangi, 2022; Tian et al., 2022).

Participants were introduced to the biological potential of *A. muricata*, particularly its secondary metabolites and annonaceous acetogenins. *A. muricata* contains diverse bioactive constituents, while annonaceous acetogenins are among the characteristic compounds associated with the biological activities of the plant (Mutakin et al., 2022). Previous studies have also demonstrated the potential of *A. muricata* leaf extracts as botanical insecticides against insect pests, including *Spodoptera frugiperda* (Khoirunnisya et al., 2022). The training also emphasized the importance of observing pest populations before treatment and monitoring plant responses following application.

Participants were encouraged to distinguish between pest reduction and complete pest elimination. The objective of environmentally oriented pest management is to reduce pest populations and plant damage while minimizing unnecessary pesticide exposure and maintaining pest populations at manageable levels. Botanical pesticides are therefore most appropriately incorporated as one component of an integrated pest-management strategy rather than being considered universally risk-free or universally superior to synthetic pesticides (Ngegba et al., 2022; Lalruatsangi, 2022; Tian et al., 2022).

Preparation of Soursop Leaf Botanical Pesticide

The practical session demonstrated the preparation of a simple soursop leaf extract using locally available materials. Fresh soursop leaves were selected, cleaned, processed, extracted, filtered, and subsequently prepared as a spray solution according to the formulation used during the activity. The selection of *A. muricata* leaves was supported by previous research reporting the biological activity of soursop leaf extracts against insect pests, although the effectiveness of the resulting preparation may vary according to extraction procedures, concentration, target species, and other experimental conditions (Khoirunnisya et al., 2022; Lengai et al., 2020). The preparation was conducted using a learning-by-doing approach. Participants directly observed and practiced each stage of the process, enabling them to develop the practical skills necessary to prepare the botanical pesticide independently. Hands-on training is relevant for community-based agricultural interventions because practical competence and user confidence are important components of technology adoption and continued utilization (Rudianto et al., 2025; Shai et al., 2024).

Evaluation and Monitoring

Program evaluation was conducted using a combination of direct observation, participant discussions, participant responses, and comparison of conditions before and after the intervention. This evaluation approach was designed to assess changes in participants' understanding, practical abilities, perceptions, and observed pest attack conditions following the community service activities. The combination of participatory assessment and direct field observation is appropriate for community-based agricultural interventions because it enables both learning outcomes and practical implementation to be assessed within the actual cultivation context (Lalruatsangi, 2022; Rudianto et al., 2025).

The evaluation covered six main indicators, including participants' understanding of botanical pesticides, their ability to identify common tomato pests, their ability to prepare soursop leaf extract, their ability to appropriately apply the botanical pesticide to potted tomato plants, changes in observed pest attack intensity, and participants' perceptions of the practicality and affordability of the technology. These indicators were selected to assess both learning outcomes and the practical relevance of the intervention for household-scale tomato cultivation. Such an integrated assessment is consistent with the broader application of botanical pesticides as environmentally oriented pest-management tools that require not only biological effectiveness but also practical accessibility, appropriate application, and user acceptance (Lengai et al., 2020; Tian et al., 2022; Merchant, 2022).

Participant perceptions were evaluated by comparing the distribution of responses before and after the community service intervention. This pre- and post-intervention comparison was used to identify changes in participants' perceived understanding, acceptance, and confidence following the educational and practical activities. Participant-oriented evaluation is particularly relevant for community-based agricultural extension because the adoption of botanical pesticides depends not only on their potential biological activity but also on users' knowledge, confidence, perceived practicality, and willingness to integrate the technology into existing pest-management practices (Lalruatsangi, 2022; Shai et al., 2024).

Meanwhile, pest conditions were assessed through observations of aphid, thrips, and armyworm populations, the percentage of damaged leaves, and pest attack scores. These indicators were selected to provide a practical description of changes in pest pressure and plant damage following the application of soursop leaf extract. Previous studies have

documented the insecticidal potential of plant-derived extracts, including *A. muricata*, against several insect pests, although the magnitude of the response may vary according to pest species, plant material, extraction method, concentration, and environmental conditions (Lengai et al., 2020; Khoirunnisya et al., 2022; Mohammad et al., 2023). The comparison of these indicators before and after the intervention provided a basis for assessing changes associated with the implementation of the community service program and for documenting participants' responses to the utilization of soursop leaf extract as a botanical pesticide. Because the activity was conducted as a community service intervention rather than a controlled bioassay or replicated experimental trial, the observed changes were interpreted as preliminary field observations and not as definitive evidence of pesticidal efficacy. Controlled studies are required to establish concentration-response relationships, treatment efficacy, application frequency, phytotoxicity, and potential effects on beneficial or non-target organisms (Lalruatsangi, 2022; Shai et al., 2024).

The overall implementation of the community service activity, including participant assistance, education, demonstration, and hands-on practice in the preparation and application of soursop leaf extract, is presented in Figure 1.



Figure 1. Photo of the Assistance Activity Process

3. RESULT AND DISCUSSION

Initial Condition of Potted Tomato Cultivation

The preliminary observation indicated that residents in the target community had already utilized limited residential spaces for tomato cultivation. Potted cultivation provided a practical option for vegetable production despite land constraints. However, the use of potted systems did not eliminate pest problems. The main pest problems identified by participants were aphids, armyworms, and thrips. Their presence was associated with leaf damage and reduced plant vigor. The occurrence of these pests also created uncertainty among residents regarding appropriate pest-management practices. Such conditions highlight the importance of improving community capacity to recognize pest symptoms and select appropriate management strategies, particularly within small-scale and household-based vegetable production systems (Lalruatsangi, 2022; Shai et al., 2024).

A major challenge was the continued use of conventional pest-control practices. Synthetic pesticides were considered practical because they were readily available and familiar to residents. However, dependence on synthetic pesticides may increase production costs and raise concerns regarding pesticide residues, environmental exposure, and effects on non-target organisms. These concerns have contributed to increasing interest in botanical pesticides as complementary tools within integrated pest management (Ngegba et al., 2022; Lengai et al., 2020; Tian et al., 2022). Botanical pesticides derived from locally available plant materials may provide an alternative or complementary option, particularly where communities have access to suitable botanical resources and can be trained in their preparation and application (Merchant, 2022; Shai et al., 2024). Therefore, these conditions demonstrate the relevance of introducing locally available botanical materials as one component of integrated pest management.

Improvement in Community Understanding

The educational component generated active participation among residents. Participants discussed the differences between synthetic and botanical pesticides, the causes and characteristics of pest attacks, and the potential utilization of plants available around the household as pest-management resources. This approach is consistent with community-based agricultural extension models in which knowledge transfer is strengthened by connecting scientific information with locally available resources and practical farming conditions (Rudianto et al., 2025; Shai et al., 2024). The learning process was strengthened through direct demonstrations and hands-on practice. Rather than relying solely on lectures, participants were given opportunities to observe the preparation process and practice the procedure themselves. This approach helped participants understand the relationship between botanical pesticide preparation, application, and subsequent pest monitoring. Practical training is particularly relevant for botanical pesticide adoption because successful utilization depends not only on awareness of botanical materials but also on users' ability to prepare, apply, and monitor their effects appropriately (Lengai et al., 2020; Lalruatsangi, 2022).

Following the training, participants demonstrated improved confidence in explaining the function of botanical pesticides, identifying visible pest symptoms, and describing the basic steps involved in preparing soursop leaf extract. These outcomes indicate that the participatory approach was relevant for transferring both conceptual knowledge and practical skills. Similar community-based initiatives have emphasized that demonstrations and direct practice can strengthen participants' understanding and practical competence in the utilization of environmentally oriented agricultural technologies (Rudianto et al., 2025). The changes in participants' knowledge and practical abilities were assessed by comparing their conditions before and after the training. As shown in Table 1, all assessed indicators demonstrated improvements following the community service intervention.

Table 1. Participants' Knowledge Before and After Training

Indicator	Pre-training (%)	Post-training (%)	Improvement (percentage points)
Knowledge of botanical pesticides	38.0	72.0	+34.0
Identification of tomato pests	46.0	78.0	+32.0
Knowledge of soursop leaf potential	30.0	76.0	+46.0
Ability to prepare extract	25.0	70.0	+45.0
Ability to apply botanical pesticide	32.0	74.0	+42.0
Average	**34.2**	**74.0**	**+39.8**

Source: Activity evaluation data.

The average level of participants' knowledge and practical skills increased from 34.2% before the training to 74.0% after the training, representing an improvement of 39.8 percentage points. The largest improvement was observed in knowledge of the potential of soursop leaves, which increased by 46 percentage points, followed by the ability to prepare the extract, which increased by 45 percentage points. These improvements suggest that the intervention was particularly effective in introducing the practical potential of soursop leaves and developing participants' basic skills in botanical pesticide preparation. The findings are also relevant to previous studies reporting biological activity of Annona muricata leaf extracts against insect pests, although the present community-service activity should be interpreted as a preliminary field-based assessment rather than a controlled efficacy experiment (Khoirunnisya et al., 2022; Mutakin et al., 2022).

Participants' Perception of the Community Service Program

The comparison of pre- and post-PKM perceptions indicates a positive shift in participants' responses following the intervention. Before the activity, the average proportion of participants selecting "Strongly Agree" was 10%, while the proportion selecting "Agree" was 38%. After the activity, these proportions increased to 36% and 69%, respectively. Conversely, negative responses declined following the intervention. The proportion of participants selecting "Disagree" decreased from 46% to 22%, while "Strongly Disagree" decreased from 8% to 0%. This shift indicates that participants generally developed more favorable perceptions toward the knowledge and practical activities introduced during the community service program. The increase in positive responses, together with the decline in negative responses, suggests that the training strengthened participants' understanding and acceptance of botanical pesticide practices. The participatory learning approach, which combined explanation, demonstration, and hands-on practice, may have contributed to participants' confidence in applying the introduced technology in household-scale tomato cultivation. Similar community-based agricultural programs have emphasized the importance of practical training and direct participation in strengthening the adoption of botanical pesticide practices (Rudianto et al., 2025; Shai et al., 2024).

The distribution of participants' responses to the Specific Instructional Objectives (SIO) was further examined to assess changes in perceived achievement of the learning objectives. Figure 2 illustrates the comparison of participants' SIO responses before and after the community service intervention.

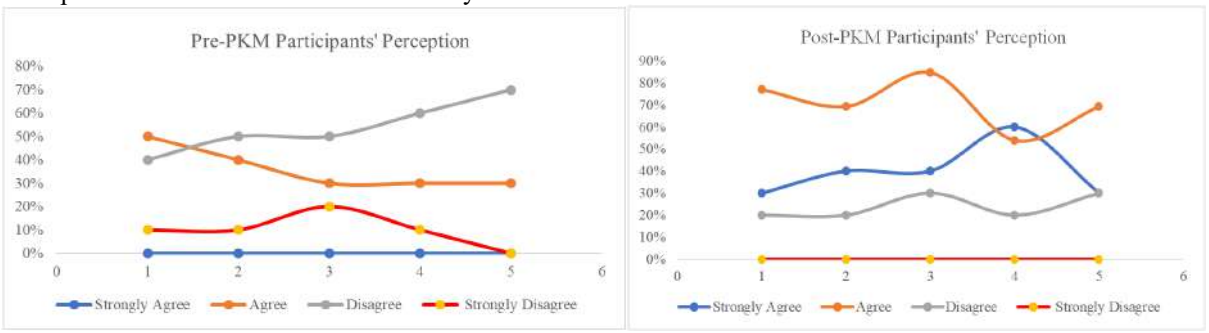

Figure 2. Participants' perceptions of SIO achievement before and after the PKM intervention.

As shown in Figure 2, the post-intervention responses indicate a shift toward more positive perceptions across the SIO indicators. The proportion of participants selecting "Strongly Agree" increased across the indicators, with the highest proportion reaching 60% for SIO 4, while the "Strongly Disagree" response decreased to 0% across all indicators. These changes indicate improved perceived achievement of the learning objectives following the education, demonstration, and hands-on activities. The result is consistent with the principle that botanical pesticide adoption requires not only awareness but also practical understanding of preparation, application, and pest monitoring procedures (Lengai et al., 2020; Lalruatsangi, 2022).

Improvement in Practical Skills

Hands-on practice was an important component of the program because participants were directly involved in preparing the soursop leaf extract rather than simply receiving theoretical information. During the activity, participants demonstrated increased confidence in preparing the extract independently. The practical session also stimulated discussions regarding the availability of raw materials, extraction procedures, application practices, and plant responses. Such practical engagement is relevant to community-based botanical pesticide programs because the utilization of botanical materials depends on participants' ability to translate knowledge into appropriate preparation and application practices (Rudianto et al., 2025; Shai et al., 2024).

The use of soursop leaves is particularly relevant to household-scale agriculture because Annona muricata is a plant containing diverse bioactive constituents, including annonaceous acetogenins and other secondary metabolites. These compounds have been associated with a range of biological activities reported for A. muricata (Mutakin et al., 2022). Previous research has also reported insecticidal activity of A. muricata leaf extracts against insect pests, supporting its potential as a botanical pesticide resource (Khoirunnisya et al., 2022). Nevertheless, the presence of bioactive compounds does not necessarily mean that every crude soursop leaf preparation will demonstrate the same pesticidal effectiveness. Biological activity can vary according to plant material, extraction procedures, concentration, target pest species, and environmental conditions (Lengai et al., 2020; Lalruatsangi, 2022; Shai et al., 2024). Therefore, formulation and application standardization would be important if the practice were to be developed beyond household-scale application.

Observed Response of Pest Attacks

Following the application of soursop leaf extract, a reduction in pest attack intensity was observed on the treated potted tomato plants. The observation provided a practical demonstration of the potential use of plant-derived materials as an alternative or complementary pest-management tool. Botanical pesticides have been increasingly discussed as components of sustainable pest-management strategies because plant-derived compounds may provide biological activity while supporting diversification of pest-management practices (Lengai et al., 2020; Tian et al., 2022).

In addition to changes in participants' knowledge and perceptions, field observations were conducted to examine changes in pest attack conditions on the potted tomato plants. The observed changes in pest populations, leaf damage, and pest attack scores before and after application are summarized in Table 2.

Table 2. Observation of Pest Attack on Potted Tomato Plants

Observation Parameter	Before Application	After Application	Reduction (%)
Aphids (individuals/plant)	18.4	6.7	**63.6**
Thrips (individuals/plant)	11.2	4.3	**61.6**

Observation Parameter	Before Application	After Application	Reduction (%)
Armyworms (individuals/plant)	4.8	1.9	**60.4**
Damaged leaves (%)	32.0	14.0	**56.3**
Pest attack score	3.2	1.5	**53.1**

Source: Field observation data.

The calculation uses::

$$Reduction\ (\%) = \frac{Before - After}{Before} \times 100$$

Examples of aphids:

$$\frac{18.4 - 6.7}{18.4} \times 100 = 63.6\%$$

As presented in Table 2, all observed pest indicators showed reductions following the application of soursop leaf extract. Aphid populations decreased by 63.6%, followed by thrips by 61.6% and armyworms by 60.4%. The percentage of damaged leaves decreased by 56.3%, while the pest attack score declined by 53.1%. These observations provide an initial indication of a reduction in pest attack intensity following the intervention. The observed reductions are broadly consistent with previous reports describing biological or insecticidal activity associated with *A. muricata* leaf extracts (Khoirunnisya et al., 2022; Mohammad et al., 2023). However, the present findings should be interpreted as preliminary field observations rather than definitive evidence of pesticidal efficacy. The community service activity was not designed as a controlled laboratory or greenhouse bioassay, and no untreated control group was used to isolate the effect of the soursop leaf extract.

Other factors, including weather conditions, natural enemies, plant age, initial pest density, and other cultivation practices, may have contributed to the observed changes. Therefore, the reduction in pest populations and leaf damage cannot be attributed exclusively to soursop leaf extract. Controlled experiments with appropriate treatment and control groups, replicated observations, and standardized extract concentrations are required to establish the efficacy and dose-response relationship of the extract against the target pests.

Potential Pesticidal Mechanisms of Soursop Leaf Extract

The potential pesticidal activity of soursop leaves can be discussed primarily in relation to annonaceous acetogenins and other secondary metabolites. Annonaceous acetogenins are characteristic phytochemicals of the Annonaceae family and have been associated with diverse biological activities of *A. muricata* (Mutakin et al., 2022). Previous literature indicates that some annonaceous acetogenins can interfere with mitochondrial energy metabolism through inhibition of mitochondrial complex I, providing a plausible biochemical basis for their insecticidal activity. In addition to potential direct toxic effects, botanical pesticides may affect insects through multiple pathways, including repellency, antifeedant activity, growth inhibition, reproductive effects, or behavioral changes (Lengai et al., 2020; Lalruatsangi, 2022; Shai et al., 2024). Consequently, the reduction in pest populations and leaf damage observed during the community activity may involve multiple biological mechanisms rather than direct mortality alone. However, the precise mechanism of action of the soursop leaf extract against aphids, thrips, and armyworms on tomato plants was not determined in the present community-service activity. Therefore, the proposed mechanisms should be regarded as literature-based explanations of potential activity, rather than mechanisms demonstrated by the current field observations. Further laboratory and controlled greenhouse studies are required to determine the active compounds, target physiological pathways, effective concentrations, and pest-specific responses.

Community Empowerment and Sustainability

The utilization of locally available plant materials has potential environmental and economic relevance for household-scale agriculture. Residents may potentially reduce their dependence on commercially purchased synthetic pesticides by incorporating locally available botanical materials into their pest-management practices. Botanical pesticides have been discussed as potentially useful components of sustainable agriculture because they can diversify pest-management strategies and may utilize renewable plant resources available within local communities (Lengai et al., 2020; Tian et al., 2022; Shai et al., 2024).

The program also demonstrated that an environmentally oriented agricultural technology can be introduced through participatory learning. Residents were actively involved in identifying pest problems, preparing the botanical material, applying the treatment, and observing plant responses. This approach has the potential to strengthen local capacity and self-reliance in household-scale urban farming. Community-based agricultural training similarly emphasizes practical participation as an important element in strengthening knowledge and adoption of environmentally oriented agricultural practices (Rudianto et al., 2025).

The activity also introduced the broader concept of resource-efficient household agriculture by demonstrating that locally available plant biomass can potentially be utilized as an agricultural resource. This concept is consistent with community-based initiatives that promote the utilization of locally available biological resources for environmentally oriented applications (Sukamdani et al., 2024; Sukwika & Paranita, 2025). However, botanical pesticides should not automatically be considered risk-free. Plant-derived compounds may affect non-target organisms, and *A. muricata* contains biologically active constituents that warrant appropriate consideration regarding exposure and safety (Mutakin et al., 2022; Shai et al., 2024). Therefore, the application of soursop leaf extract should be accompanied by appropriate education concerning responsible application, unnecessary exposure, protection of beneficial organisms, and proper handling.

Botanical pesticide use should also be integrated with non-chemical approaches such as field sanitation, removal of heavily infested plant parts, regular pest monitoring, and physical pest control. The long-term sustainability of the practice depends on continued technical assistance, availability of raw materials, consistency of preparation methods, and participants' willingness to integrate botanical pesticides with other pest-management strategies. Standardization and periodic monitoring are therefore important for supporting continued adoption at the household level. To provide an overall comparison of participants' perceptions before and after the community service intervention, the distribution of responses across the four perception categories is summarized in Figure 3.

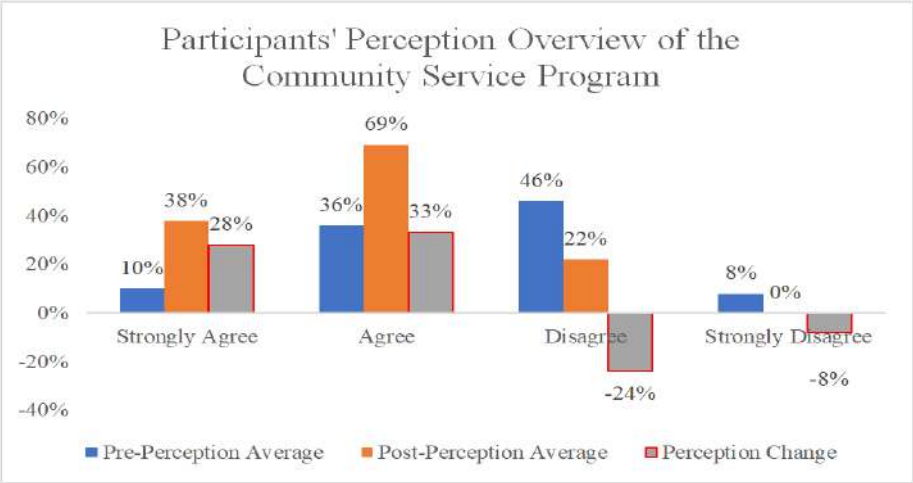

Figure 3. Comparison of Participants' Perception Responses Before and After the PKM Intervention.

Participants' perceptions of the community service program showed a positive shift following implementation of the activity on the utilization of soursop leaf extract as a botanical pesticide for potted tomato plants. The proportion of participants selecting "Strongly Agree" increased from 10% before the activity to 36% after the activity, while "Agree" increased from 38% to 69%. In contrast, "Disagree" decreased from 46% to 22%, and "Strongly Disagree" decreased from 8% to 0%. This shift indicates a general movement from negative toward positive perceptions and suggests that the intervention was positively received by participants. Overall, the findings indicate that the objectives of the community service program were satisfactorily achieved, particularly in increasing participants' knowledge, practical skills, and positive perceptions regarding an environmentally oriented alternative for pest management in household-scale tomato cultivation. Nevertheless, the observed pest reductions should be considered preliminary and should not be interpreted as definitive evidence of the causal efficacy of soursop leaf extract. Further controlled research is required to validate its effectiveness, determine appropriate concentrations and application intervals, and assess its safety toward non-target organisms

Limitations

Several limitations should be considered when interpreting the findings of this community service program. *First*, the activity was conducted at the community level and was not designed as a controlled experimental trial. Therefore, reductions in pest populations and leaf damage cannot be interpreted as definitive evidence of the efficacy of soursop leaf extract. *Second*, quantitative information regarding pest mortality, concentration-response relationships, treatment replication, and tomato yield was limited. These variables should be incorporated into future controlled studies. *Third*, the chemical composition and biological activity of botanical extracts may vary depending on plant maturity, environmental conditions, extraction procedures, concentration, and storage. Consequently, formulation standardization is necessary before the technology can be recommended as a consistent botanical pesticide. *Fourth*, further research is required to assess phytotoxicity and possible effects on beneficial insects and other non-target organisms. The term "botanical" does not necessarily mean that a pesticide is completely risk-free.

4. CONCLUSION

The community service program demonstrated the potential of soursop (Annona muricata) leaf extract as a locally accessible botanical pesticide for household-scale potted tomato cultivation. Through participatory education, demonstration, and hands-on practice, participants gained greater understanding and confidence in identifying pest problems, preparing botanical pesticide, and applying the treatment to potted tomato plants. The comparison of participants' pre- and post-PKM perceptions showed a positive shift toward stronger agreement with the achievement of the program's learning objectives. The proportion of participants selecting Strongly Agree increased from 10% to 36%, while the Agree response increased from 38% to 69%. Conversely, Disagree decreased from 46% to 22%, and Strongly Disagree decreased from 8% to 0%.

The reported observation data also indicated reductions in pest populations following the application of soursop leaf extract. Aphids decreased by approximately 63.6%, thrips by 61.6%, and armyworms by 60.4%. The percentage of damaged leaves decreased by 56.3%, while the pest attack score declined from 3.2 to 1.5. These results provide an initial indication of the potential usefulness of soursop leaf extract for environmentally oriented pest management in potted tomato cultivation. However, these findings should be interpreted as preliminary community-level observations rather than definitive evidence of pesticidal efficacy, because the activity did not employ a controlled experimental design. Further research should examine different extract concentrations, application intervals, pest-specific suppression, phytotoxicity, effects on beneficial organisms, persistence, and tomato yield. Controlled experiments are required to establish the efficacy and consistency of soursop leaf extract before it can be recommended as a standardized botanical pesticide.

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